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UNDERGROUND INSECT DESTROYERS OF THE WHEAT PLANT.

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BULLETIN
OF THE
OHIO AGRICULTURAL EXPERIMENT STATION.

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UNDERGROUND INSECT DESTROYERS OF THE WHEAT PLANT

BY F. M. WEBSTER.

In a previous bulletin of this station (second series, vol. V, No. 4.) the writer gave an account of such species of insects as burrowed in the stems of the wheat plant, usually above the surface, but sometimes going below ground. In this publication attention will be given entirely to such as injure the stems of the plants below ground exclusively, and are known as subterraneous, except, perhaps, in the case of *Diabrotica 12-punctata*, whose larvæ sometimes attack corn slightly above the surface, though as yet known to injure wheat only below ground.

WIRE WORMS.

(Ord COLEOPTERA Fam ELATERIDÆ)

(Slender, brown, wiry worms, with three legs on each side of the body some distance behind the head, Fig. 1, living in the ground on the roots of grass and grains. In wheat they cause plants to wither and die in the drill rows, sometimes only one or two plants being eaten, while in others their ravages extend along the row for several feet.)

Notwithstanding these larvæ are among our most troublesome pests, the literature relating to their habits in this country is not only very much scattered, but meagre and unsatisfactory. Dr. T. W. Harris, it is true, devoted about six pages of his valuable work to this family of beetles, directing attention to the destruction caused in Europe by the larvæ of similar species.

Fig. 1. Wire Worm, natural size.

Dr. Harris[1] especially noticed three American species of Elaters which were then, as now, supposed to be among the most injurious.

These were *Melanotus (cinereus) fissilis* Say, *M, communis* Gyll, and *Agriotes mancus* Say. Fortunately, adds the author, the ravages of these insects are as yet inconsiderable, but we may expect them to increase in numbers in proportion as we disturb them and deprive them of their

[1] A treatise on some of the Insects Injurious to Vegetation. By Thaddeus William Harris, M D., 1841. Revised by author, 1852. Re-revised by Charles L. Flint, 1862, pp. 52-57.

natural articles of food, while we continue to persecute their natural enemies, the birds. The fact that both the larvæ and adult beetles occur in low, damp localities in greatest abundance was recorded, but, with this exception, no original observations were given. It was not long, however, before the columns of the agricultural press began to contain reports of the ravages of these wire worms, thereby proving the correctness of the suspicions of Dr. Harris. Even as early as 1847 Mr. F. C. Clopper stated that wire worms were very destructive to many crops in Montgomery county, Maryland.[2]

In 1866, Dr. Asa Fitch, Entomologist to the New York State Agricultural Society, devoted twenty-four pages of his Eleventh Report on the Insects of New York,[3] to giving, as he expressed it, "as full an account of the wire worms, their habits and economy, as my means of information will enable me to prepare." This report, although printed over twenty years ago, is still the best published notice we have. While drawing freely from the writings of Bjerkander upon Sweedish species, and from the writings of Curtis upon European species, Dr. Fitch gives a *resume* of such facts as had come under his personal observation, and also of such complaints and communications as had appeared in the agricultural periodicals of the day. Besides this he describes the supposed larvæ of *Agriotes* (*truncatus*) *maucus* Say, and (*Cratonychus*) *Melanotus communis* Gyll., substantiating the assertion of Dr. Harris, with regard to their abundance about grass lands in low, damp localities. He also records the fact, so noticeable to more recent observers, viz., the abundance of adult *M. communis* under the bark of old logs and stumps, while *A. mancus* is never found in such places. The eggs of another species, *Ludius attenuatus* Say, were described, and a single female of which had been observed to deposit 126 eggs in the earth.

The Wheat Wire Worm.

Agriotes mancus Say.

Up to 1870, our knowledge of this species remained practically as left by Dr. Fitch, in 1886. In the fall of the former year, Mr. J. Pettit, of Ontario, Canada, placed in flower pots examples of a species of wire worm, which was at the time seriously affecting wheat in his neighborhood, and supplied them with food by frequently sowing wheat in the earth therein. These larvæ fed voraciously until cold weather began, when they ceased, but began again with the opening of spring, and continued to feed until July. From this time until the 26th of August the absence of Mr. Pettit prevented his observing them, or even providing food for them. But, on examining the

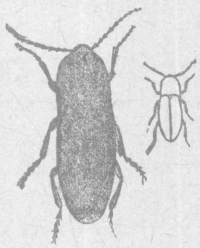

Fig. 2. Adult, natural size and enlarged

[2] U. S. Agricultural Report, 1849–50, p. 130.

[3] Eleventh Report on the Noxious, Beneficial and other Insects of New York. By Asa Fitch, M. D., Annual Report, State Agricultural Society, 1866, pp. 519-43

earth in the pots on his return, a single pupa was found, and on the 3d of September, an adult *Agriotes mancus* appeared, followed during the month by two others. Seven adults were also found in cells in the earth, these cells evidently having been formed by the larvæ prior to their pupating.

When the larvæ were placed among the pots, one individual among them was observed to be not over half the size of the others. Among the pupa and adults found in the pots, was a larva now about the size of the others when placed in the pots the fall before, and which Mr. Petitt considered as the same individual, hence he concluded that not over three years was required for the insect to pass from the egg to the adult. Probably they do, however, require a few months over three years, the eggs being deposited in spring and adults emerging in late summer.

Mr. Pettit's[4] paper was accompanied by descriptions and illustrations of the larva and pupa by Dr. G. H. Horn, and altogether formed a most excellent, as well as the first, contribution to an exact knowledge of our native wire worms.

Professor S. A. Forbes[5] states that he has observed the larvæ of this species as late as July 1st, devouring the roots and burrowing into the stems of corn just above the roots, in sufficient numbers to affect about six per cent. of the stalks in some fields near Peru, Illinois.

In the year 1885 Mr. Eli Elser, of Huntington, Indiana, complained of serious damage to young wheat by wire worms, specimens of which accompanied his letter. The worms proved to be the larvæ of *Agriotes mancus*.

During the fall of 1887 serious injury to wheat was reported from various portions of Indiana. A field in LaGrange county, which had been cultivated for a number of years, was damaged thirty-five per cent. The ground had been cleared except of the larger stumps, five or six years previous, and continually cultivated, the stumps being blown out and burned during the spring of 1887. The ground was then plowed and harrowed twice in June, cultivated once and harrowed several times prior to September 15, when the crop afterwards so seriously injured was sown.

Mr. F. P. Applegate, of Greensburg, Decatur county, suffered seriously from attacks during October, in a field which had produced clover one season, being plowed in March and planted in corn among which the damaged wheat crop was sown in September,

Mr. J. A. Applegate, of Mt. Carmel, Franklin county, reported the most seriously injured field in his neighborhood as being one that had been two years in corn, rye being sown in the fall among the second corn crop, the rye being plowed up in the spring and the land sown to Hungarian, and on this being harvested the ground was again plowed and the after-

[4]Canadian Entomologist, Vol. IV, p. 3.

[5]Miscellaneous Essays on Economic Entomology, p. 18, 1886.

wards damaged crop of wheat sown thereon.[6] The species is becoming more and more destructive in Indiana, and the majority of complaints are of injury to the second crop after grass or clover, especially if of wheat.

While none of the American elaters have been reared from the egg to the imago, there is very good reason for the belief that they pass through their cycle within the space of a little more than three years. Besides Mr. Pettit's observations, it is well known among farmers that these wire worms usually do little or no damage, except during the first and second years following crops of grass. And it is a curious fact that, as a rule, the major part of the damage to wheat is done the second year.[7] This state of affairs could hardly exist if a longer period were required for the insects to pass through their preparatory stages.

Just why these larvæ should work greater destruction the second season of the cultivation of fields than they do the first, is by no means easily explained. The probabilities are that there would be many more larvæ in the earth the first year, and that with any radical curtailing of the food supply the younger and weaker larvæ would be the more apt to suffer or be destroyed The most plausible theory is, that enough roots of grass survive the first plowing to afford food for the worms the first season, but the plowing for the second year's crop of grain destroyed all grass roots, thereby compelling the worms to look to the growing crop for sustenance.

The observations of Dr. Fitch[8] as to the adult *A. mancus* not being found under the bark of logs and stumps in the woods has been frequently verified by other entomologists, and we have swept this species in great numbers from clumps of willow, *Salix discolor* Muhl., on the prairies of Illinois during warm evenings in summer, and found it to be the most abundant of all the elaters, among the debris left by the smaller streams after having been suddenly swollen by a heavy summer rain.

Remedies.

Of the many remedies which have from time to time been proposed as a means of destroying wire worms, none have yet met the requirements of the extensive western farmer, and, indeed, even the efficiency of many of the proposed measures is, to say the least, doubtful. A fruitful source of error, with regard to the results of experiments with remedial measures, is that the non-appearance of the pest in destructive numbers, following an application of a remedy is taken as proof of the latter's efficacy, when, as is more often the case, this non-appearance was due either to the fact that the larvæ had all transformed the previous summer, or had ceased to feed prior to pupating.

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[6] Report Commissioner Agriculture, 1887, p. 153.

[7] Indiana Agricultural Report 1885, p 216

[8] Eleventh Report Insects New York.

Both salt and lime have been applied to infested fields, and while good results have been occasionally reported to follow, there has always been a lack of proof that the result was due to the application. While, on the other hand, Hon. A. B. Dickenson, in an address before the Cortland county (N. Y.) Agricultural Society, delivered in 1855, stated that he had sown ten bushels of salt per acre, and again had applied one hundred bushels of lime per acre without effect.[9]

During the spring of 1889 we made some experiments with salt for destroying wire worms, applying at the rate of 470 lbs., 940 lbs., and 24,500 lbs. per acre respectively. In neither case was the corn protected nor the worms destroyed at the end of five days. Gas lime was tried upon an English species by Mr. Edward Gordon, of Kelton Hill, Kirkcudbright, England, without apparent good.[10] Mr. J. R. Dunn, of Stone House, Hawkhurst, Sussex, states that both rolling and treading by cattle and sheep failed to prevent crops from being destroyed,[11] while Mr. D. Sturdy, of Trigon, Wareham, found that the larvæ throve on Indian Rape (mustard cake).[12] Miss Eleanor A. Ormerod, Hon. Consulting Entomologist to the Royal Agricultural Society of England, states that a mixture of one part paraffin to fifteen of water has been used with very good results among gardeners in North England,[13] and the editors of the Rural New Yorker report satisfactory results from the use of sulphur in the trenches of a number of different varieties of potatoes, the wire worms seeming to be repelled by the sulphur.[14] The same publication some years ago[15] recommended guano as an excellent preventive, and Miss Ormerod reports an instance where a mixture of guano and superphosphate of lime was drilled in with wheat (corn) on pasture land broken up the previous year. Where the mixture was not used the plants perished by the worms, but where it was applied a good yield was obtained, although worms were found between the drills.[16] Hog manure, according to the statement of D. Thomson, of Adams Basin, N. Y., is an entire preventive. Parts of a field where this manure was plowed in and in certain rows where it was dropped in the hill a good yield was obtained, while other parts of the field not treated were destroyed.[17] However, as stated by Dr. Fitch,[18] the benefit of highly manuring, thereby promoting a rapid growth, is admitted on all hands, and hence all fertilizers are indirectly at least of some value, even though they may not prove an effective re-

[9] Fitch Eleventh Report.
[10] Report of Injurious Insects for 1883, by E A. Ormerod, p. 38.
[11] Loc. cit., p. 39.
[12] Loc. cit.,
[13] Manual of Injurious Insects, p. 96.
[14] Rural New Yorker Oct. 31, 1885.
[15] Rural New Yorker, 1862, p. 29
[16] Manual of Injurious Insects, p. 94.
[17] Rural New Yorker, Vol. VI, p. 133.
[18] Eleventh Report.

pellant. In countries where labor is cheap and the fields not large, hand-picking is carried on to advantage and is doubtless by far the most effective, 60,000 worms, according to Curtis, having been collected in this way from a space of three acres. Mr. Hogg, of England, may years ago tried trapping the worms by laying down pieces of lettuce on the ground and picking off the worms as they gathered on these, while Sir Joseph Banks substituted potato for the lettuce. Mr. Adams used half a potato with the eyes removed. This he planted in the ground with about an inch of loam, running a pointed stick through it, so as to find it readily, and in this way trapped from fifteen to twenty at a time.[19] Pairing and burning the sod has been recommended by Mr. Walsh, and also later by Miss Ormerod,[20] who also suggests mixing the sod with gas-lime, instead of burning.

Treating the seed with obnoxious or distasteful solutions has been tried; but the results, as reported, are very conflicting. Soaking the seed in copperas water is one of the first methods that is apt to suggest itself to the farmer. Dr. Cyrus Thomas, formerly State Entomologist of Illinois, states that farmers of Macoupin county, that State, failed to obtain relief by the use of the solution in that manner.[21] Coating with tar and rolling in lime, ashes or gypsum, were tested by Mr. Ezra Tucker, of Peoria, Illinois, and he gives the result of using tar in the "Prairie Farmer," Vol. XII, p. 209, 1851, as follows: "The corn must be soaked say twelve hours in hot water, as to soak seed in water made only a little more than lukewarm would not swell the seed sufficiently to ensure germination, and the tar effectually varnishes over each kernel, so that no more moisture can come to the corn, and consequently most of the seed will not come up. I have seen whole fields fail to come up." Upon the same point Gen. Wheeler, Steuben county, N. Y., states that tar used upon seed corn previous to planting retards germination.[22] "Tarring seed corn against wire worms is of no use," said Levi J. Hopkins in "Country Gentleman," May 15, 1856. Besides the foregoing objections as to the efficacy of these measures, they all necessitate soaking the seed, which enlarges and softens it, thus precluding the possibility of planting with the two-horse corn planters now in general use. Professor J. H. Comstock found that the adult beetles could be easily trapped and destroyed. The most successful devices for baiting consisted, first, of poisoned corn meal, sweetened with sugar, and moistened to form a dough, placed in shallow tin plates, sunk to a level with the surface of the ground, and, second, small bunches of clover poisoned with Paris green water, or Zocktein, and placed under boards. This last device was found to be the most successful in attracting and destroying the beetles.[23]

[19] Gardeners' Chronicle, Vol. 3, p 301.

[20] Loc cit., p. 92.

[21] Seventh Report State Entomologist Illinois, p. 31.

[22] Transactions New York Agricultural Society, 1860, p. 55.

[23] Bulletin 3 Cornell University Experiment Station, Nov., 1888.

There remains only one other way of dealing with this pest, and that is by starvation, which may be accomplished by three different methods: first, by seeding the ground to a plant distasteful to them; second, by allowing the field to remain fallow for one year, and keeping all vegetation from growing; and third, by fall plowing and cultivating in spring, delaying the planting to the latter part of May or even in June. For the purposes of the first, both White Mustard and Woad are extensively used in England, but in the United States Buckwheat is the only plant that has been used for the purpose, and against this it is claimed that the crop is uncertain and the seeds left in the field spring up and prove a great pest the following year. Besides, the experience of Mr. A. G. Percey casts some doubt upon the reliability of the measure. He states that having had two acres of corn growing in a low spot in an old meadow totally destroyed, he sowed the ground to buckwheat during the last of June, also sowing a strip of corn in order to see which would be the most injured. As a result, the worms seemed to relish the seeds of buckwheat quite as well as the corn, and destroyed between one-fourth and one-half of them, and a crop of wheat sown on the ground the following autumn was almost destroyed by them.[24] But, while there seems to be some doubt as to the efficacy of buckwheat as a destroyer of wire worms, any farmer will admit that there is no crop that will leave a field of sod in better condition for cultivation, and it certainly does destroy the roots of grass most admirably. The second measure finds little favor with the American farmer, and the majority prefer to risk a crop of corn rather than lose the use of the field for the entire season.

Regarding the effect of the third method there is the usual difference in results said to have been obtained. Dr. Fitch[25] cites two instances where fall plowing was reported as a total failure so far as the effect upon the worms was concerned; one of the parties even advocating spring plowing and immediate planting, by which he expected to get his corn started while the worms were still feeding upon the roots of the grass. But this latter experiment has, to my personal knowledge, been tried by Illinois and Indiana farmers to their sorrow. The general opinion among western farmers is that fall plowing has a good effect. Mr. J. B. Smith, of Queensville, Jennings county, Indiana, during a discussion of the subject at an annual meeting of the State Board of Agriculture,[27] stated that he had been in the habit of breaking up old pastures for corn, and where he had practiced fall plowing he had experienced less difficulty with wire worms, and he believed that fall plowing was the remedy.

The best time to fall plow has not been very exactly determined; but so far as any direct effect upon the worms is concerned, it is very probable that plowing immediately before the ground freezes, and deep

[24] Rural New Yorker, Vol. 13, p. 86.

[25] Fitch's Eleventh Report.

[27] Indiana Agricultural Report, 1885, p. 218.

enough to throw the larvæ up to or near the surface, would affect them. Very early and shallow plowing of sod would have the effect of killing more of the roots of grass, and thus cutting off the food supply in spring, but would not be likely to affect the worms in the fall, from the fact that we have kept wire worms in earth in a flower pot, without feeding them, from August until April, and they survived without apparent effect. For some reason corn planted about the first of June in the latitude of northern and central Indiana and probably Ohio is the least injured by wire worms.

Natural Enemies.

Among the natural enemies, the crow is doubtless the most useful, and what testimony we have on the subject goes to show that elaters and their larvæ constitute a large portion of its food. B. F. Ashton, of White Creek, N. Y., on breaking up a crow's nest containing the unfledged young, found the crops of each of these to contain seventy or eighty snapping beetles.[28] A more recent observation is recorded by Professor Theo. G. Lemmon, of Westport, Missouri, in a paper read before the State Horticultural Society at its 29th annual meeting. The Professor shot and examined the contents of the crops of a number of crows about Lexington, Missouri, where the ravages of wire worms had been very severe, and found that they contained a sufficient number of these insects to warrant the assurance that the crow is the untiring enemy of the wire worm.[29] Birds of the Thrush family (Turdidæ) are also valuable auxiliaries to the good work of the crow. In studying the food of these birds, Professor S. A. Forbes estimated that two per cent of the food of the robin, during the entire year, was made up of these insects in their various stages. The brown thrush and the Alice thrush had been equally efficaceous, and the wood thrush had eaten three per cent, while the hermit thrush came in with only one per cent.[30]

Blackbirds also came in for a share of the credit. Two examples, shot in an orchard in Central Illinois during May, proved to have eaten, among other food, four per cent of Elaters.[31]

Two other preventives may be referred to as promising favorable results. First, rapid rotation of crops, thereby leaving the fields only a short time in grass, and, second, underdrainage.

As to the effect of the latter there are in the west, where an immense amount of drainage of this sort has been done, confusing reports as to its effect on the wire worms, some farmers claiming favorable results, while others report precisely the opposite. These diverse reports may, perhaps, be accounted for from the fact that the adults select the low, damp localities in which to oviposit, and though underdrained, they continue

[28] Fitch's Eleventh Report.

[29] Colman's Rural World, January 27, 1887.

[30] Bulletin No. 3 Illinois State Laboratory Natural History, pp. 80-148.

[31] Loc. cit. Bulletin No 6, p. 24. (table).

to infest them, because they are still the best adapted to their requirements, when in grass, notwithstanding the soil may be much dryer than formerly.

Melanotus communis Gyll.

Though described in 1817, this species seems to have been continually under condemnation by reason of its abundance, and while there is no doubt that it had long been destructive this was not actually proven by rearing until the year 1885, at least so far as any published account is concerned.

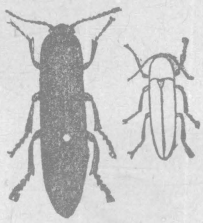

Fig. 3. Adult, natural size and enlarged.

Larvæ of species of Melanotus have long been considered very destructive to corn, especially in the western states upon lands which have previously been for some years devoted to pasture or meadow. From such a field, which had been broken up and planted with potatoes, on August 17th, 1885 the writer obtained a number of wire worms and placed them on the surface of the earth in a flower pot. All of the larvæ, except one, immediately burrowed their way out of sight, but the one remaining pupated within a few hours and was covered with loose earth and left to develop A few days after the flower pot was accidently overturned and larvæ and pupa destroyed, The potato field was, however, again visited at once and other pupa obtained from which *M. communis* was obtained, and also adults of the same species were found in cells in the earth about the field. These facts indicate that the species reached the adult stage during August or September, the pupal season occupying but a short time.

During the same year Professor S. A. Forbes[32] seems to have reared an adult from a large number of larvæ taken in the act of depredating upon corn.

In the spring of 1892 the young wheat on the experiment farm, then located at Columbus, Ohio, was seriously injured by the larvæ of this species, fully 10 per cent of the plants in one field withering and dying late in May. Another field, separated from the first only by a narrow drive, was scarcely injured. Both fields lay along the Olentangy river, and both were of undrained bottom land, with soil of the same nature. The history of the two fields was as follows: The injured field was in clover in 1888 and remained thus until September, 1889, being cropped in June and again in August, 1889; plowed September 1st to 15th, 1889, and sown to wheat; clover was sown among wheat in spring of 1891; the stand of clover was poor and the ground was plowed again in September, 1891, and again sown to wheat. The field least injured was also in clover in 1888, plowed in spring of 1889 and planted to corn; plowed in spring of 1890 and again planted to corn; plowed in spring of 1891, sown to oats, and plowed again in August and sown to wheat.

Tabulated, the relative treatment of the two fields would be as follows:

[32] Misc. Essays on Economic Entomology, p. 17, 1886.

INJURED.	UNINJURED.
1888. Clover.	1888. Clover.
1889. Clover. Plowed in Sept., wheat.	1889. Corn. Plowed in spring.
1890. Wheat. Plowed in Sept., wheat.	1890. Corn. Plowed in spring.
1891. Young clover with wheat. Plowed in Sept., wheat.	1891. Oats. Plowed in spring. Plowed in August, wheat.
1892. Wheat.	1892. Wheat.

On the one hand we have a three-year series of fall plowings without rotation of crop, and on the other a three-year series of spring plowings and a rotation of crop. For my own part I can only attribute the immunity of the spring plowed field to that fact alone, though the rotation with oats might have had some effect. The worms working in the wheat were all very nearly full grown and it would seem that they were from the eggs deposited in the injured field in the spring of 1889, and after the uninjured field had been plowed. Our present understanding in regard to these insects is that the eggs are laid in spring and the adults develop in midsummer of the third year. This would indicate that it was worms from the 1889 deposit that injured the wheat. This puts the matter of fall plowing of sod in about this light: It probably has a tendency to reduce the number of worms in the field, but admits of one additional generation, and therefore the pest will continue to work one year longer in fall than in spring plowed grass fields.

WHITE GRUB.

Lachnosterna fusca Frohl. (and others).

Ord. COLEOPTERA: Fam. SCARABÆIDÆ.

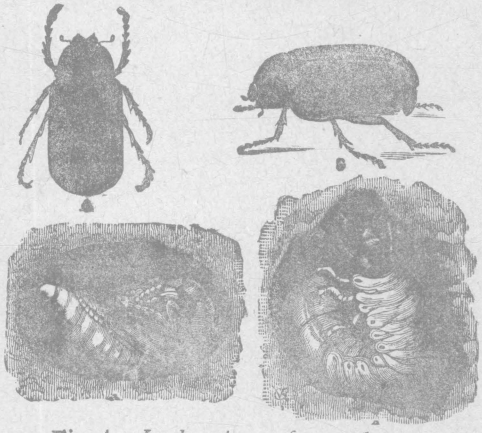

Fig. 4. *Lachnosterna fusca*. 1, pupa; 2, larva; 3-4, adults. After Riley.

A robust, white worm, with brown head, and an inch or more in length, Fig 4, 4, which eats off the stems of young wheat below ground.

The larvæ of the group of beetles to which this species belongs are known the world over as preeminently root feeders, and their reputation as destroyers of grain is older than the science of entomology itself. Linnæus speaks of a species (*Scarabæus melolontha*) as being the most mischievous of all European insects, the grub of which devours the roots of corn (grain) and other vegetables. And, as if this were not enough, he adds that if the beetles appear in autumn in considerable quantities, they are said to forerun epidemic disorders[33].

The species under consideration was, up to 1826[34], known as *Melolontha quercina* Koch, but Dr. Harris then proposed the generic name of *Phyllophaga*, by which it was known until 1837[35], when (Dr. Harris having never published a generic description) it was designated under the genus *Lachnosterna* by Rev. F. W. Hope. In 1857[36], Dr. Fitch, on tracing its history, found that it had been described in 1792 by Frohlich, under the specific name *fusca*.

A very noticeable feature of the writings of the earlier American entomologists is that very little is said of the destructive habits of the larvæ, especially to grain. Harris says that, in its perfect state, the beetle feeds upon leaves, particularly those of the cherry tree, and that the larvæ devour the roots of grass and other plants. While Dr. Fitch, writing in 1857[37], says that during the previous twenty-five years, he had never known the adults to strip trees of their foliage, or the turf to be severed by their larvæ, although he had heard of a number of cases of the latter. And yet the insects were common in his neighborhood every year.

Notwithstanding the silence of both Harris and Fitch on the subject of the depredations of these grubs, in the cornfields of America serious trouble had long been experienced.

John Josslyn, who made a voyage to New England in 1638 and 1639, and again in 1663 remaining until 1671, in his account of his second voyage, in speaking of the cornfields of the aborigines, says: "There is a Bug that Lyes in the earth and eatheth the seed, that is somewhat like a Maggot, of a white color with a red head, and about the bigness of one's finger and an inch or an inch and a half long[38]."

Mr. Jacob Cist stated in 1824 that he had known one-third of the

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[33] General System of Entomology Ed. by Wm. Turton, M. D., Vol. I, p 46, 1806.

[34] Insects Injurious to Vegetation, p. 30.

[35] Loc. cit

[36] Genesee Farmer, Aug 1857, pp. 239-41.

[37] Loc. cit

[38] Second Voyage, p. 115.

corn crop to be destroyed by them, as many as ten to fifteen being found in a single hill[39].

Wm. S. Wright, of Sugar Grove, Licking county, Ohio, states that in 1849 "the grub worm was a serious enemy which had destroyed much corn in that locality during the last few years."[40]

Mr. B. D. Walsh, of Rock Island, Illinois, writing in April, 1866, gave three instances where corn had been seriously injured by white grubs,[41] and followed his citation by expressing astonishment that these larvæ should be increasing so rapidly. One of the instances given by Mr. Walsh, where serious damage had been done, had come under his personal observation twenty years previous, when he had observed the larvæ destroying young corn, growing in a field of prairie land broken the preceding year. The second instance was communicated to him in a letter from Sanford Howard, Esq., Secretary of the Michigan State Board of Agriculture, who stated that in the vicinity of Prairie Ronde, in his State, previously noted for its great corn crop, these grubs had nearly destroyed many fields. They had first been observed nine or ten years previous, he himself having visited the locality in August, 1864, and found that farmers were being obliged to sell their hogs in a lean state, for want of corn to fatten them. He had examined the fields and found the roots of the corn generally eaten off within a few inches of the stock, and observed from three to five grubs in the hill. The third case was at Nine Mile Prairie, Missouri, where large patches of corn had been destroyed in the fields, which facts had been communicated to the Valley Farmer, of November 15, 1865, by Mr. Huron Bust.

Prof. Riley, writing in 1868, designates the white grub as the very worst and most insidious of the farmers' foes.[42] In this notice the author states that "Soon after pairing the female beetle creeps into the earth, especially whereever the soil is loose and rough, and after depositing her eggs, to the number of forty or fifty, dies. These hatch in the course of a month, and, the grubs growing slowly, do not attain full size till the early spring of the third year, when they construct an ovoid chamber, lined with a glutinous fluid, change to pupæ and soon afterwards to beetles.* These last are at first white, and all the parts soft as in the pupa, and they frequently remain in the earth for weeks at a time, till thoroughly hardened, and then on some favorable night in May they rise in swarms and fill the air." In 1872[43] the same author describes the egg,

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[39] Sill Am. Jour. Sci. VIII, p 269, 1824.

[40] Pat. Office Rep. (Agr.) 1849-50, p 175.

[41] Practical Entomologist, Vol. I, p. 60, April 1866.

[42] First Report Insects of Missouri, pp. 156–59.

[43] Loc. cit., Fifth Report, p. 55.

*Prof. S. A. Forbes (Rep. St. Ent. Ill., 17th p. 31.) has shown that the larvæ largely at least pupate in late summer and fall and pass the winter in this stage. We have however found both pupæ and larvæ, the latter evidently nearly or quite full grown, in October and November. F. M. W.

and states that they are deposited between the roots of grass and are enclosed in a ball of earth, evidently formed by the ovipositor of the female, as the cavity is frequently large enough for the egg to roll about in.

From what facts we are able to obtain, it would appear that, as the country has become more and more thickly settled, and the natural haunts of these larvæ broken up, they have been driven from the native sod to the pastures and meadows, and as these have been broken up, they have become more conspicuous. Another reason for their comparatively recent occurrence as a pest of the cornfield is, that, with the first opening up of the western country, wheat was raised much more extensively than corn. But the spring wheat belt is gradually moving westward, and is followed by corn. In Illinois, where in 1861* a large majority of the fields were producing spring wheat, there is now hardly an acre sown, the major part of these lands being devoted to either corn or grass. Hence, the increased destruction may be as much due to the change in the crop as in the numbers of the insects. At present, however, the pest occupies a position co-equal with the wire worms and cut-worms In fact, some farmers claim that it is the most serious pest of them all.

In his letter, previously quoted, Mr. Sanford Howard states that on Prairie Ronde, Michigan, the larvæ are much more destructive about every third year. This periodical occurrence is reiterated by Prof. Riley, but their appearance at different times, in different localities, makes it rather difficult to turn this characteristic to economic account.

Aside from grass and corn, Mr. B. D. Walsh[44] stated that in Illinois in 1861 the grubs worked in great numbers in small grain and also among young trees, cutting away and devouring the roots of the young plants. Several years ago that veteran grower of forest trees, Mr. Robert Douglass, of Waukegan, Illinois, stated to the writer that the white grub was his his most serious pest, they destroying long stretches in the rows of young forest trees in his nursery Mr. Walsh[45] and Dr. Thomas[47] also recorded long ago the serious depredations of these grubs among strawberries, and also among lettuce. Dr. J. A. Lintner states that in 1881 these grubs were charged with having devoured whole fields of potatoes in Washington county, New York, and ruined hundreds of bushels in North Pawlet, Vermont, in 1884.[48]

We have observed them eating off the growing plants of buckwheat in July. Singularly enough these grubs have never been recorded as injuring growing cotton, although several species of *Lachnosterna* are

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[44] Trans. Ill. St. Ag. Soc, Vol. 5, p. 469.

[45] Prac. Ent., Vol. I, p. 60.

[47] Trans. St. Ag. Soc. Ill., 1865, p 411.

[48] Bull N. Y St. Mus Nat Hist., 5, p. 10.

* 1861 was the last favorable spring wheat year, in northern Illinois, from which time it declined until 1870, when the grain was seldom sown

very abundant in the southern states, and we have observed larvæ destroying corn in Louisiana.

Of the food habits of the beetles of this genus authors have from time to time given us important information. That they ate the foliage of trees was well known, even to Linnæus. Harris states that they are very destructive to the foliage of fruit trees, especially the cherry.[49] Dr. Fitch mentions the plum as being seriously injured. Mr. B. D .Walsh[50] stated that in May, 1862, at Pana (Ill.?) swarms of *L.* (*pilosicallis*) *tristis* Fab. appeared and destroyed the roses, leaf and bud, nearly finished the raspberries, and were said to have injured grape vines, peach and maple trees. Dr. Riley states that the Lombardy poplar is sometimes destroyed in consequence of denudation caused by these beetles, while *Quercus palustris and Q. obtusiloba* are also injured.[51] Mr. W. L. Devereaux, of New York, states that the walnut and ash are likewise attacked,[52] to which Dr. J. A. Lintner adds the beech.[53]

Remedies.

Up to the present time neither the entomologist nor the agriculturist has found an efficient, practical remedy or preventive. Not only is this true of America, but equally so of European countries. "The Society of Arts in London, during many years held forth a premium for the best account of this insect and the means of checking its ravages, but without having produced one successful claimant."[54]

Although allowing fields to remain in grass but two years in succession and plowing in the fall seems to meet with the greatest favor among farmers, yet during some seasons these precautions appear almost useless. If the plowing in the fall be succeeded by a mild winter there appears to be little effect. But the impression prevails generally that if the weather is sufficiently severe during winter to freeze the ground to the depth of say ten inches or more, late fall plowing reduces the number of grubs. But this measure is only applicable to the cooler countries, and is therefore useless in tropical or sub-tropical localities.

Starving out, by destroying all vegetation may be practiced, and while considerable merit has from time to time been claimed for the measure, no extended experiments have been made in the field, with sufficient care to indicate the practicability of such preventives.

The very common error is continually committed of doing certain things after a season of severe attack, and the result of the disappearance the following year which would have occurred naturally, is construed

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[49] Inj. Ins., p. 28.
[50] Trans. St Ag. Soc. Ill., 1865, p. 469.
[51] First Rep Ins. Mo., p. 157.
[52] The Husbandman, June 23, 1886.
[53] Bull. N. Y. St. Mus. Nat. Hist., 5, p. 11, 1888.
[54] Harr. Inj Ins., Ed. 1841, p. 25.

into the effect of remedies applied. The limited amount of food consumed by the young larvæ would necessitate an almost total extermination of the plants, root as well as stems. Besides, as these larvæ do not appear in such immense numbers at regular periods, it would be necessary to follow up the measure every year, in order to be sure of including the right one.

The application of substances to the ground, with a view of destroying the grub, has long been advocated, but, as yet, no great benefit has been derived, nor, indeed, has the fact of efficiency without harm to the crop been fully established, except in some cases where the expense of the substance and its application would be too great to admit of its being profitably used. Under this last category will come caustic lime wash, carbon bisulphides, carbolic acid, etc.; salt, lime, ashes, tobacco water, gas-tar water, ammoniacal water and decoction of burdock leaves have all been tried by the writer, but in no cases were the grubs killed without killing the plants also. In some cases, notable with the burdock decoction, the grubs appeared to forsake the roots of plants and crawl to one side, probably to return after the effects of the application had been effaced by absorption, rains, etc.

Gas-lime is frequently recommended, but does not seem to have been tested in a manner to definitely settle its efficiency or utility. Miss Ormerod[55] states that in England this substance had been sprinkled on the land without keeping off the Chafers, and suggests shoveling on in a thin layer over the ground. We have had no opportunity of testing this substance, nor have we, so far, been able to induce farmers to do so. It is, however, very doubtful, even if effective when applied in large quantities, whether it can be practically utilized by the extensive farmers of the western states. Kerosene emulsion, consisting of one part kerosene to four parts water, was tried at Columbus, Ohio, by Mr. Wm. B. Alwood, and found to be effective only on grubs placed in loose soil, as in grass lands they would crawl away, out of reach of the mixture.[56]

Later, it was found that the effect could be emphasized by drenching the earth with water some hours after applying the emulsion, but this so increased the labor and expense as to render the measure impracticable.[57]

In all of Mr. Alwood's experiments, where larvæ were apparently effected by emulsion, he states that a black spot appeared on the grubs supposed to have been affected. While the appearance of this spot might have been due to the effect of the emulsion, yet such conditions do not necessarily follow, as, during the autumn of 1889, in Indiana, in cornfields where grubs were very abundant about hills of corn, this same feature was observed by the writer, and, besides, it was sufficiently common to attract the attention of farmers. Wherever this was noticed,

[55] Agr'l Stud. Gazette (Cirencester, Eng.) April 1883, I, p. 73.

[56] Bull. 13, U. S. Dept. Agr., Div Ent., p. 39.

[57] Insect Life, Vol. I, p. 48.

more or less of the grubs perished, the spot seemingly spreading over the entire body, which finally turned black.

The beneficial effect of barnyard manure as against the white grub, both in field and garden, has frequently been remarked. Just why this is true has not been definitely ascertained, but certain it is that portions of fields fertilized with the accumulation of barnyards have suffered much less from ravages of the grubs than portions not thus treated. This feature was observed during the severe attack of 1889 by many farmers in Indiana and reported verbally to me. That the same effect is to be found in the garden and fruit farm is shown by a notice published in the "Orange Judd Farmer" of December 15, 1888, in which Prof. W. J. Green, Horticulturist of this Station, stated that experimental plats of strawberries, even when the plants were actually set in grub infested land, escaped serious injury by being fertilized with manure, while other plants all around them, fertilized with salt, potash, superphosphate, sulphate of ammonia and nitrate of soda, were not in the least protected.

While it is true that this measure to some extent relieves only the small farmer, it is to him and the gardener and fruit grower a practical measure, and its effect on the grubs is not the greatest benefit to be derived from its use.

Trapping the beetles has often been recommended, the method employed being some form of light placed on a stand in the midst of a shallow receptacle which is filled with water, on the surface of which is a thin film of kerosene. A convenient modification which can be arranged cheaply and expeditiously is to hang an ordinary lantern just above a tub of water floating a thin stratum of kerosene. The beetles in flying about the light fall into the tub and are killed. Great numbers of beetles can be destroyed by shaking them from the branches of trees on which they cluster to feed. Neither of these measures in which lights are used is likely to prove of much effect as a protection to the foliage of fruit trees; besides, it is questionable if after all more beneficial insects than injurious are not thus destroyed.

Natural Enemies.

The natural enemies of both grubs and adult beetles are quite numerous, and of these bats, crows, poultry and swine have been known since the days of Linnæus.[58] Harris[59] quotes Latreille as authority for including the badger, weasel, martin, rat and night-hawk, all presumably feeding on the adults, and himself adds the skunk and the jay, the former being accredited with destroying beetles, and the latter feeding their young on the grubs.[60] Mr. S. S. Rathvon[61] appears to have been the first

[58]Turtons Linnæus, Vol. I, p. 46.
[59]Inj. Ins., p. 28.
[60]Loc. cit., p. 28.
[61]Rep. Comm. Agr., 1861, p. 601.

to record the fondness of the skunk for the larvæ, but since that time few years of abundance have passed without ample proofs in the fields of the tastes of his skunkship. During the autumn of 1889, in Indiana, the soil about the roots of corn which had been killed by grubs in fields, in many cases would be pawed away and small cylindrical holes would appear, showing where the skunks had dug out the depredators.

Dr. Cyrus Thomas[62] gives the raccoon, Dr. Lintner[63] the fox, and Dr. Hoy the frog,[64] and Professor Claypole the mole, as other vertebrate enemies.[65] Mr, Jacob Cist,[66] as early as 1824, recorded the blackbird as a most useful ally in destroying the grubs. Professor Forbes[67] found remains of members of the genus Lachnosterna in the stomachs of the robin, catbird, brown thrush, wood thrush, and the red-headed wood-pecker.

The insect enemies of either the adult beetles or grubs are few in number. Dr. Riley[68] some years ago described and figured a Hymenopterous parasite, *Tiphia inornata* Riley, one of the digger wasps which burrows down into the earth and deposits its eggs upon the bodies of the grubs. The writer found a larva of a species of *Erax* near ***bastardii*** about hills of corn killed by grubs under circumstances which strongly indicate that it had destroyed the depredators, but after they had finished their work.

A species of fungus, *Torrubia ravenelii* Berkeley, has long been known to attack white grubs, but seldom in sufficient numbers to effect any perceptible diminution of the pest. It is doubtless this species to which Mr. Jacob Cist referred in a note published in 1824 and accompanied by figures of diseased grubs.[69] At this time, however, the fungus was not known as an enemy to insects, but was supposed to originate from the sprouting of seed eaten by the grubs. This fungus makes its appearance from between the head and anterior pair of legs, extending forward sometimes several inches. The most extended and recent notice of this fungus is by Dr. C. V. Riley,[70] who described the species in 1875, but later discovered Berkeley's description and called attention to the fact that it held priority over his own.[71]

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[62]Sixth Rep. Ins 111, p. 98.
[63]Bull. 5 N. Y. St. Mus., Nat. Hist, pp. 17-18.
[64]Trans. Wis. St. Ag'l. Soc, XIX, 1881, p 297.
[65]Can. Ent. XIV, p. 17.
[66]Am. Jour. Sci. and Arts, Vol. 8, p. 269, plate IV.
[67]Bull. St. Lab. Nat Hist. 111, 3, 6.
[68]Sixth Rep. Ins. Mo., 1874, pp. 123, 124.
[69]Am. Jour. Sci. and Arts, Vol. VIII, p. 269, pl. 4, 1824.
[70]Am. Ent., Vol. III, 1880, pp. 137-40,
[71]Rural World, June 12, 1875.

THE SOUTHERN CORN ROOT-WORM.

Diabrotica 12-punctata Say.

(Ord. COLEOPTERA: Fam. CHRYSOMELIDÆ.)

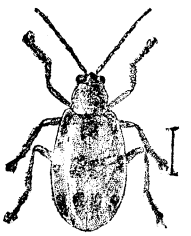


Fig. 5. Adult *Diabrotica 12-punctata.*

This is closely allied to the Striped Cucumber Beetle, and the two may often be found in company on squash and melon vines. The larva has been found by me in the fall feeding on the stems of wheat below ground. The insect was fully treated and illustrated in Bulletin 45, and therefore no extended notice is required here.

CRANE FLIES: LEATHER JACKETS.*

(Ord. DIPTERA: Fam. TIPULIDÆ.)

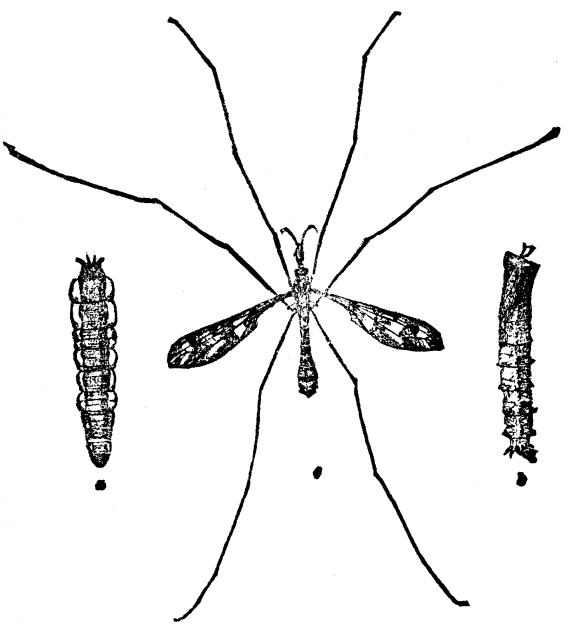


Fig. 6. *Tipula hebes* Loew. *a*, larva; *b*, pupa; *c*, male adult. After Weed.

*Extracted with some changes from my Report as agent of the Division of Entomology of U. S. Department of Agriculture and published in Bulletin No. 26, of that Division.

(Large, dirty white, footless maggots, Fig. 6, *a*, which destroy the wheat plants in early spring by gnawing the tender stems below ground.)

"Any extended study of the species belonging to this group of insects, the Tipulidæ, is impeded by many obstacles, owing, first, to the great difficulty of securing a proper determination of the species involved, and second, to the fact that they are among farmers to a considerable extent associated with cutworms, the larvæ being known as cutworms and the adults as "cutworm flies;" so that it is not only a difficult task to indicate the exact insect, but equally so to secure accurate data with respect to its habits in the fields. In England these insects have long ravaged fields of young wheat sown after clover, but in this country such attacks have not often been observed.

With the increasing popularity of clover-growing, both for pasture, meadow, seed, and fertilizer, it would appear that we are on the verge of a new era with respect to the effects of these insects in our clover fields; and even now one who watches them carefully and notes the numbers of adults which are often to be observed about our clover fields can not help but suspect that they are working an injury which we either fail to observe, or, observing, attribute the loss occasioned thereby to other causes. So far as grain crops are concerned, the indications are that the American husbandman will have little trouble in preventing serious ravages in his fields. What the future of our clover lands is to be, especially if allowed to remain intact for a number of years, is yet to be seen. Of the species studied, there is not one the ravages of which can not be almost entirely prevented in young wheat by plowing the ground during late August or early September, and there is every reason to believe that if the fall growth of clover is kept mowed or grazed off during September and October little trouble will likely follow from the depredations of the larvæ the following spring. Some species, notably the ones studied in the Indiana fields in 1888 and 1890, are two brooded, the eggs being deposited in spring and fall, while *Tipula costalis* Say. which was reared from the field at Ashland, Ohio, and also a species near or identical wilh *Tipula angustipennis* Loew, are probably single brooded, ovipositing during late September and October only.

Tipula bicornis Loew.

On May 17, 1888, we received the following note from editors of the *Anderson Herald*:

ANDERSON, IND., *May 16, 1888.*

We send you by to-day's mail a bottle with some worms which are taking the place of cutworms in our county. We send them to have them named or to find out the name.

THE HERALD COMPANY.

We visited the locality on May 23d, but could learn of but one infested field, this being on the farm of Mr. J. C. Beesom, located about 3½ miles from the city of Anderson. This field consisted of twenty-two acres of under-drained clay loam, with the soil of the depressions darker colored, the surface, however, being nearly level. The field for the two preceding seasons had been devoted to red-clover pasture, but not pastured during the last year after about August 1. After this date there sprung up a rank growth of clover, and, besides, a great number of rag-weeds (Ambrosia.) During March of 1888 the clover had been almost totally killed, the owner thought by the weather. About April 16 Mr. Beesom began to break the field, and then discovered myriads of these larvæ, which were new both to him and his neighbors. At this time, from a square foot of ground he took two hundred of the larvæ, and did not dare to plant his fields from fear of these worms destroying his crop. On May 16 he found them still in the earth in immense numbers, and noticed that a considerable percentage had disappeared—doubtless pupated.

When I visited the field fully 90 per cent were in the pupal stage, their numbers fully confirming Mr. Beesom's statement as to the number of larvæ, the lower and darker colored spots being the worst infested. There were, at the time of my visit, very few adults to be found in the grass along the edges of the field, but in the sod, which was that of Blue Grass, no larvæ or pupæ could be found. Although the two stages were pretty generally distributed over the whole area of the field, they were especially abundant under clods, turf, or half-covered bunches of weeds and other débris. On the level plowed ground the pupæ could be detected by round holes which they occupied in a vertical position. Under the clods this feature was not so noticeable; although in these cases they seemed to favor the edges of their coverts. The country was originally thickly wooded, but has for a long time been cleared up, except frequent groves, which are usually pastured. The infested field was one cleared by pioneers many years ago.

The advanced stage of development to which the insects had already attained precluded the possibility of thorough study in the field, especially of the larval habits, and hence we were obliged to be content with a few and a good supply of pupæ, with which we returned home.

After the general habit of these insects the pupa occupies a vertical position in the earth, and the adult, just prior to emerging, pushes from one-half to two-thirds of its body above the surface. In this position a large number of pupæ were placed in breeding cages and the result most carefully watched. The first adult, a male, appeared on May 25, and did not burst from the pupa until after the latter had been protruding from the earth for several hours. The pupa case first bursts along the head and prothorax, and the head and shoulders of the adult first appear. Until enough of the body has been delivered to clear the tips of the wings, egress is brought about by muscular extension and contraction of the abdominal segments After the wings are free, but while still in its vertical position, the imago changes its tactics, and begins to rock gently backward and forward, drawing up the legs slightly at each backward motion, until they are finally withdrawn from the case, and the now nearly emerged insect bends forward with the nearly empty pupa case and crawls forth. In the case of the female, loaded down with her burden of eggs, the assistance of the male is often required to finally extricate her.

On the 26th a large number of adults of both sexes emerged in the breeding cage, followed on the 27th by still greater numbers, the males in the majority; but hardly to the extent indicated by Mr. Beesom in the following letter, received a few days later:

ANDERSON, IND., *May 29, 1888.*

MR. F. M. WEBSTER:—According to promise I will give you a history of the worms and fly. On May 26th the flies were very numerous around the fences, multiplying each day until the 29th, when the field was swarming with the "gran'daddy long-legs." On the same day there was some not yet hatched, but not many, and some were just coming out. I watched their habits, and think from appearance there was about one female to one hundred males. The female is full of eggs when hatched; has about three hundred eggs of a jet black color. I saw the male helping the female out of the shell. He would do this by standing upright with the female pushing back and forth. In this case the shell would be half way out of the ground. As soon as he would get her out he would impregnate the eggs. This is about all I can tell you now.

Yours etc.,

J. C. BEESOM.

Soon after emerging, sometimes within a few hours, the female begins her work of oviposition. Three newly emerged females, placed separately in glass tubes, produced respectively 297, 282 and 289 eggs. In confinement, these eggs were thrown off at the rate of from three to ten per minute.

That this species is double-brooded there is no reasonable doubt, later observations showing that the eggs of the fall brood are deposited principally during September, the insect wintering over in the larval stage and finishing this stage in early spring, its period of development being a little later than the following species, although the two may be found abundantly at the same season, the next species appearing first and seeming to be well advanced in the work of oviposition by the time this begins to appear in noticeable numbers.

Respecting natural enemies, Mr. Beesom had observed great numbers of crows and "bee birds" hovering about this field almost constantly, and he was quite positive that they were engagsd in the destruction of the larvæ. From what has already been stated, it seems probable that the adults are, to some extent at least, destroyed by the catbird. Of the probable insect enemies, *Pterostichus lucublandus* was particularly abundant, and Mr. Beesom at once pointed them out as the most numerous in the field, and particularly where the larvæ were then congregated. *Harpalus pennsylvanicus*, *H. caliginosus*, and *Pterostichus femoralis* were also present in considerable numbers, as were also the larvæ of some species of Harpalus and Platynus, these larvæ being especially abundant in places where the pupæ of the Tipula were massed.

As clover was seriously injured throughout the West during the winter and spring of 1888, any attempt to estimate the injury occasioned by these worms would, of necessity, be mere guesswork."

In the Sixteenth Report of the State Entomologist of Illinois, Prof. S. A. Forbes gives a full account of the work of the larvæ of this species in the meadows of central and southern Illinois during the seasons of 1886 and 1887, accompanied by a description of all stages of development except the egg, with a fine illustration of the larva. That portion of the paper relating to the habits, distribution and destruction caused by these larvæ I give in full, as it is of much interest to Ohio farmers

"Concerning a single species, the commonest here in 1886 and 1887, I have recently collected information which shows it to be capable of at least intensifying the damage done by drouth to meadows of clover, blue grass and timothy. A very general and serious injury to grass and clover lands in many parts of southern and central Illinois—severest and most general to the southward—was frequently associated in those years with great numbers of large, dirty gray, footless maggots—the larvæ of this insect—found among the roots, where the latter had been so eaten away that the plants were killed and loosened from the ground, often in patches of considerable size. Specimens collected here contained in their stomachs a mixture of dead and living vegetation,—roots and leaves of grass,—as did others placed in sod and kept under observation in breeding cages."

"This species hibernates as a larva nearly or quite full grown, as shown by our collection made in Edwards county, April 6, 1888, and in Effingham county on the 16th. At Edgewood nearly all had changed to the pupa by the 3d of May, at which time a single larva was also found, and a single empty pupa case. Breeding-cage specimens from southern Illinois began to emerge May 4, and continued to do so until the 28 of May. By May 10, these flies were found common in meadows near Carbondale; and at Urbana, May 19, they appeared at the electric light and flying about in meadows. The latest specimens of the season were collected May 31. No eggs were obtained, but pairs were seen in copula late in May (19 to 31) in both fields and breeding cages. The immediate copulation of the imagos, and the immense numbers of eggs presently developed by the female, together with the early disappearance of the winged fly, are all evidence that the eggs are soon laid. The time of hatching was not ascertained.

"Our first observations on possible injuries by these insects were made at Albion, in Edwards county, April 6, 1888, when these larvæ were found in great numbers at the roots of timothy and clover which had been killed the previous year —the injury first attracting attention shortly after the fields had been mowed. The timothy had here suffered worst, the bulbs, whose roots had been cut away just below the surface, lying in great numbers on the ground. The larvæ were at the surface in April, feeding largely on dead vegetation. In some parts of the field they averaged one or two to the square foot; and occasionally nearly every stool of timothy was infested. April 16 a similar condition of meadows was found at Edgewood, similarly associated with the tipulid species above described,—the injury being here much more general (chiefly in timothy meadows) than in Edwards county. Here, as in the other situation, the timothy bulbs could often be raked up by the bushel, the roots having been generally eaten away. The fields infested were of various ages, one of the worst—on which there had evidently been an excellent stand—being but two years old. Here, as before, the maggots varied in number from one to two or three per square foot.

"As there was nothing in these observations to make it certain that these larvæ had done the damage with which they were connected, experiments were made to ascertain their feeding habits. Tipulid larvæ from these situations were placed, April 16, in pots of sand with growing oats and wheat, and ten days later were dissected for a study of their food. A single larva examined had the alimentary canal well filled with vegetation, full ninety per cent. of it fresh roots. The dead matter was not impossibly from food taken before the experiment began.

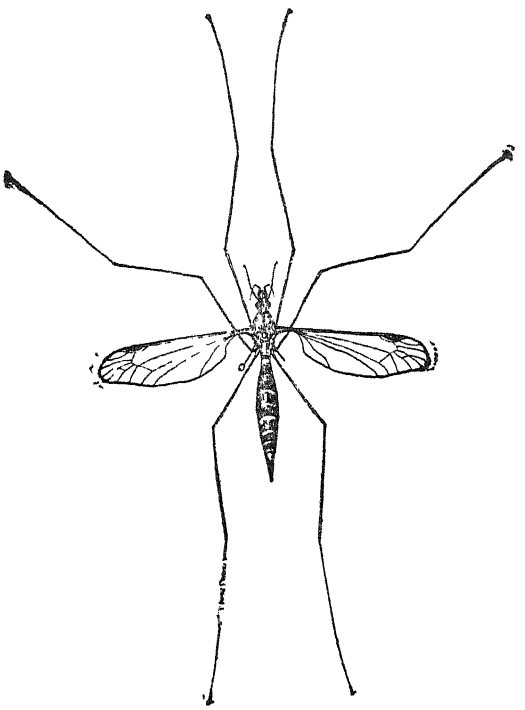
"On the other hand, two specimens from among the dead grass at Albion, collected there the 6th of April, had these proportions of food reversed, about four-fifths to nine-tenths being now derived from dead grass and the remainder from living. At Edgewood, however, where the vegetation was less thoroughly killed, about two-thirds of the food of two specimens and about one-half that of another consisted of fresh grass leaves. These particulars create, it must be admitted, only a presumption to the effect that these tipulids were responsible for a considerable part of the damage to meadows in southern Illinois; but their habit of mixed feeding makes evident their capacity for mischief where they are exceptionally abundant, and where drouth or other unfavorable conditions render grass specially sensitive to insect attack.

"To learn the extent of the phenomena above reported, a circular of inquiry containing a brief description of the larva and of its supposed injuries was addressed to the crop correspondents of the State Department of Agriculture. In reply, Mr. C. L. Sweet, of Glenwood, Cook county, wrote, April 25th, that he had found an insect answering completely to my description in dead patches of his meadow, which he had first noticed the preceding fall. From Eberle, Effingham county, Mr. Geo. Strong wrote of the occurrence of the meadow maggot in no very great numbers, adding that his attention was first attracted to it by the work of the hogs in pasture and meadow, rooting up patches of the sod. From San Jose, Mason county, Mr. Wm. M. Duffy wrote that deadened patches such as I described were very numerous, and that on May 4 he found in these patches a few of the maggots mentioned. From Arlington, in Bureau county, Mr. Louis Zearing wrote, April 25 that this insect was not a new thing in his vicinity, but made its first appearance there fifteen years before, its ravages being then almost exclusively confined to blue grass sod. From Milton, Pike county, Mr. J. O Bolin reported that for two years these insects had injured his pastures in small patches, mostly blue-grass sod; and Mr. E. H. Robb, of Waynesville, DeWitt county, wrote, April 27, that he found them in both meadow and pasture by the thousand, having first noticed them some six weeks before, when breaking up meadow for corn.

"The injuries thus far reported are not of a gravity or frequency to make special remedial measures seem important. Indeed, in the Old World, where these insects are very much more destructive than here, and have been long well known, no remedies have been devised which are satisfactory or would apply to our agricultural conditions If our species becomes so destructive as to require special attention, it will probably be found best to plow up the sod and plant to some other crop It is worthy of remark, however, that in a case reported from Los Angeles, California, by Dr. Riley, great numbers were destroyed by driving a flock of three hundred sheep over their haunts Close trampling of the earth by the slow passage of a drove of pigs would doubtless answer the same purpose, which is that of destroying the larvæ lying free upon the surface or barely imbedded among the roots of the grass."

The Thick-Nosed Crane Fly.*

Pachyrrhina sp.?



Pachyrrhina sp?

Fig. 7. Adult female.

"Late in April, 1890, news came to me of the depredations of a new insect pest in fields of young wheat near Farmersburg, Sullivan county, Ind. This time the depredators proved to be the larvæ of a species of *Pachyrrhina*, but whose depreda-

*Extracted substantially from my annual report as agent of the Division of Entomology of U. S. Department of Agriculture, and published in Bulletin No. 26 of that Division.

tions were very much like the preceding; a visit to the locality on the 26th, and especially to the fields of Mr. T. H. Kendall, revealing the nature of the depredator and the effect of its ravages. The insect was at that time most abundant in the pupal stage, these pupæ, after the manner of the *Tipulidæ* in general, occupying vertical cells in the ground. Larvæ were, however, present in considerable numbers, both in the earth and on the surface, the day being rainy, and not only about the wheat plants, but also about stray clumps of timothy, of which there were a considerable number scattered over the field among the wheat. For reasons which will appear further on, the numbers present in both stages did not correspond at all with the reports of Mr. Kendall, nor with the amount of damage clearly attributable to the pest. The most seriously injured fields were those which had been in clover the previous year.

"Of two fields adjoining each other, one sown on oat stubble, the other on clover sod plowed early in October, the latter was damaged fully 50 per cent., while the former had escaped uninjured. Another field a short distance from these, also in clover last year but plowed late in August, was damaged only about 15 per cent. A clover field adjoining the first two had been completely ruined, but this might have been in part due to the winter, although the insect was present in abundance. A close inspection of the most seriously injured field showed large areas of grain totally destroyed, while other areas among them were little injured. The plants themselves had not been thrown out by the frost, but were well fixed in the soil. The day was rainy, and many of the dead plants had a green appearance like that of wetted hay, and did not at all resemble those killed by frost or freezing, indicating that they had withered.

"Mr. Kendall stated that up to the 1st of February his wheat was in fine condition, but after that time it began to die, and continued to do so rapidly until about the first week in April, since which time the depredations had gradually ceased. Soon after the trouble began he had observed the larvæ in myriads both above and below ground, but they worked below, not cutting off the plants, but apparently wounding them and sucking the juices. In working about just beneath the surface of the ground they raised ridges like those made by moles, but about the size of straws, and the earth immediately about the plants was often worked up as if by ants or earth-worms.

"A large number of larvæ and pupæ were secured and taken home, in order that I might be able to study the method of feeding in the former, secure adults, and watch the oviposition of the females, which, I judged, might differ from those previously studied in case they proved to be of a different species. While collecting this material, not only many dead pupæ were noticed, but larvæ also, lying on the surface of the ground, many of which had turned black wholly or in part, after the manner of diseased cabbage worms. This led to the suspicion that they had been attacked by a fungous disease, which had reduced their number and consequent injury. While all living material was, on my arrival home, placed in a breeding cage and thus kept out of doors, nearly all of the pupæ were destroyed, almost entirely, I believe, by this fungoid enemy, which Dr. J. C. Arthur informs me is undescribed, and for which he proposes the manuscript name *Empusa pachyrrhinæ*. One larva constructed its cell in the earth in the breeding cage and transformed to the pupa, but the next day this pupa worked itself upward out of the cell and was found lying on the surface dead, and covered with spores of Empusa. How much this fungus had to do with the stopping of depredations of the larvæ on the wheat it is, of course, impossible to say, but it must have destroyed a large percentage of the pest.

"The first adult appeared in the cage on the 28th, two days after removal from the field. Other adults emerged so very sparingly, and at such long intervals, that no opportunity was offered to secure fertilized eggs or note the ovipositing habits of the females. The first of the only two females reared was nearly dead when a male

emerged, and, though fertilized, died without ovipositing, and the male refused to pair a second time, leaving the second female without a mate, she dying before a second male emerged. Two females and four males were all the adults secured from the material brought home, the others, as I believe, having been destroyed by the Empusa previously mentioned.

"The same species was found in abundance in clover fields about Lafayette during the whole of the month of May, eggs being secured on the 28th from a female taken in the field. We have this year reared adults which appeared June 4. About the 10th of August males began to appear again in great abundance, and both sexes were observed on the 15th, and by the 27th they seemed to be in the height of the ovipositing season; but the females stubbornly refused to oviposit in confinement, and it was only by securing a female while laying her eggs in the field that I secured an additional supply, though I saw a female which had been caught in a spider snare depositing her eggs freely. By the 20th of September the species had nearly disappeared, only spent females being seen, though the present season, near Columbus, Ohio, one was observed filled with eggs as late as the 22d. It seems, therefore, that the ovipositing seasons are, as a rule, from about May 1 to June 15 and from about August 10 to September 25, the period covering about six weeks.

"On May 7, 1891, I received a number of Tipulid larvæ from Mr. D. F. Wise, of Ashland county, Ohio, with the statement that they were present in one of his fields in myriads, and he was afraid to plant corn therein through fear of their destroying his crop. The owner described the infested field as having been devoted to wheat three and two years previously, yielding about 20 bushels per acre; was seeded to clover, and last year a crop of hay was removed. This spring, however, the clover had disappeared and the entire field of 14 acres furnished only feed enough for twenty-two ewes and their lambs. From these larvæ I reared, June 4, a male and female of this species. Mr. Wise wrote me later that he had observed these worms in his clover fields, and had noticed unaccountable injuries thereto for the last nine years, but thought the intruders were ordinary cut-worms. About the first of April, this year, he began tiling his field, and on the following morning found the bottom of the ditch, though covered with water, was swarming with these larvæ, and the fact of their living in water raised the suspicion that they were not true cut-worms. On May 16, nearly six weeks later, he wrote that those larvæ were still living in the ditch.

"When I received the larvæ from Mr. Wise they were placed in a large glass with considerable earth and a clover plant, but no drainage. After waiting a considerable time for other adults to emerge from the larvæ, I concluded that the remainder had died, and paid no further attention to the glass in which they had been placed."

Tipula costalis Say

"Early in July an examination of the earth in the glass mentioned above, now nearly a solid mass, showed several larvæ, and, what was more surprising, they were still alive. During my removal from Lafayette, Ind., to Columbus, Ohio, and the rearrangement of things, this glass accidentally became filled with water, and remained so for nearly two weeks, when, judge of my astonishment on examining the contents, ten larvæ were found alive and completely submerged in the water, one floating about with its posterior upward. The larvæ were at once removed and placed in a flower-pot, in which a fresh clover plant was placed, and this kept watered. Nothing appeared until September 20, when a male emerged, followed on the next day by a female. These were kept together, and, though copulation took place, the female stubbornly refused to oviposit, and died without furnishing me with a single egg. The same day on which the latter of these two adults emerged, while riding along the highway, myriads of both sexes were observed. Under date of

September 19, Mr. J. M. Jones, of Dunkirk, Hardin county, wrote that they had appeared about the 15th inst. and were literally swarming. All facts taken together indicate that this species is single-brooded, the eggs being deposited late in September or early in October.

Mr. Wise states that the larvæ of these Crane-flies are most abundant in low, grayish-black soil, and where the ground is the wettest, and that during heavy rains they appear to work nearer the surface of the ground. He also states that to his knowledge they have never injured corn planted in these fields. Mr. Wise stated sometime later in the season that the corn in the field infested by the larvæ of this species did not yield half a crop. The plants were thrifty until in August, when they suddenly ceased to grow, with the result stated. Roots sent me showed unmistakable signs of attacks by insects, such attacks not being made until after the plants had become well rooted, after which a vast number of small roots had been thrown out to replace the larger ones destroyed. While, therefore, it is as yet too much to say that *Tipula costalis* is a corn-destroying insect, there seems a prospect that future study may prove it to be such.

From the foregoing it seems that our clover fields are menaced by at least three species of Crane-flies, one of which is known to be, under certain conditions, exceedingly destructive to wheat, while the other two may rest under grave suspicion. In a former report to this Department I clearly showed the desirability of sowing wheat late in the fall—the exact time depending upon the locality—as a protection against the fall attack of the Hessian fly. It seems now that though sowing should be deferred, plowing, in cases where wheat is to follow clover, should be done late in August, or at least before the middle of Septomber, in order to escape injury from the larvæ of Crane-flies.

Besides the enemies of Crane-flies already given, I have observed an ant, *Aphænogaster fulva*, attack and drag away a living female of Pachyrrhina, and in addition to the bird enemies given by Mr. Beesom the following is a list of birds found to have preyed upon these insects in Illinois (see Bull. State Lab. Nat Hist. Ill., No. 3, pp. 104–135):

Species of bird.	No. of birds examined.	Ratio of food composed of Tipulidæ.
Robin	114	.01
Catbird	70	.05
Wood Thrush	22	.12
Alice Thrush	11	.08
Swainson Thrush	11	.04

From a short note published in Bulletin 43, p. 131, it will be observed that the larvæ of these crane-flies enter but little into the food of robins, as is indicated by the tabular statement of Prof. Forbes. There is little likelihood of these insects causing serious injury in the wheat fields of the northern portion of the State, but in the south where wheat is sown later to avoid the attack of Hessian fly the danger is much greater. Even here, however, the trouble may probably be avoided by plowing the ground early in September. They are really more likely to prove injurious in corn and meadow lands.

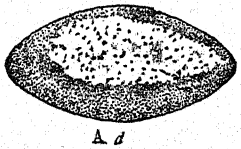
SUMMARY.

Wire Worms are the larvæ or grubs of snapping or click beetles, and breed especially in low, damp, cold soils, feeding on the roots of grass

and, probably, other herbaceous plants. They probably require a little over three years to develop from the egg to the adult. No thoroughly practical method of destroying these worms has as yet been discovered. Their numbers may be reduced by fall plowing, and their haunts rendered unattractive by a rapid rotation of crop and by under-drainage. Where fields of corn are attacked and replanting is made necessary, it is best to plant the second time between the old rows, allowing the latter to stand as long as possible in order to hold the attention of the worms and keep them diverted from the latter plants.

White Grubs are the offspring of the May Beetles or June Bugs. While the wire worms develop to adults in summer and live over winter in that stage, the white grubs pass the winter either as grubs or pupæ, and develop to adults in spring, otherwise the life history of the two is much the same. The eggs are laid in the ground, notably in grass lands, and hatch in about 30 days. The young work little injury the first year, but the next they ravage the fields most seriously. These grubs prefer the higher to the lower lands, and therefore drainage has much less effect upon them. Probably fall plowing and rapid rotation of crop are the best methods to pursue. Fertilizing with barnyard manure is a protection against damage in infested fields.

Crane-flies are known also as Gallinippers, and many term them cut-worm flies, though they have no connection with cut-worms. There are a number of species of these, some of which are one and others two brooded each year. The eggs are deposited in grass and clover lands, more particularly in low, flat, damp lands. The maggots feed on the roots, seldom appearing above ground except in very wet weather. The ravages of these larvæ can be prevented in wheat lands by plowing early in September. This measure will also preclude the probability of injury to corn the following year. For injuries in grass or clover lands no remedy or preventive is as yet known.



A *d*

Egg of *Tipula bicornis*. Magnified about 35 times. Original.